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**Ohio State Engineer**

**Title:** Egyptian Irrigation Works

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**Issue Date:** May-1924

**Publisher:** Ohio State University, College of Engineering

**Citation:** Ohio State Engineer, vol. 7, no. 4 (May, 1924), 9-10, 15, 28.

**URI:** <http://hdl.handle.net/1811/33635>

**Appears in Collections:** [Ohio State Engineer: Volume 7, no. 4 \(May, 1924\)](#)

# EGYPTIAN IRRIGATION WORKS

O. B. STOUT, C. E., '24

**O**UR earliest conception of Egypt (see any elementary treatise on Geography) is a land of intense heat and dry, shifting sands whose awful monotone is relieved here and there by an occasional oasis sheltering a caravan of nomadic traders. The more modern version seems to be a land much overrun with "sheiks" and speckled with sepulchres whose contents would make Solomon (were he alive) green with envy. The Egypt with which this article deals is like neither. It embraces the Nile Valley from

useful or far reaching in beneficial results upon the industrial welfare of the people than this dam."

Previous to the construction of Assuan Dam, the inhabitants depended upon the more or less makeshift method of "basin" irrigation. The annual overflow from the Nile at flood, which occurs from August to November, was turned into basins or natural depressions in the ground. The water in these basins was controlled by means of crude gates and in some cases by mere earthen dams of sand and silt. After a basin was filled, the water was allowed to stand for a time and was then turned into another depression at a lower elevation. By these means the land was saturated with water and the rich alluvial deposit so necessary to the cultivation of crops was allowed to settle upon the land. The grain was then planted and a fair degree of success was attained. The chief objection to this method other than its lack of efficiency has been the absence of any organization or control of the available supply of water. In particularly dry years, the lands of the upper regions were naturally more favored. When there was a plentiful supply no one suffered, but no water was stored for the dry season.

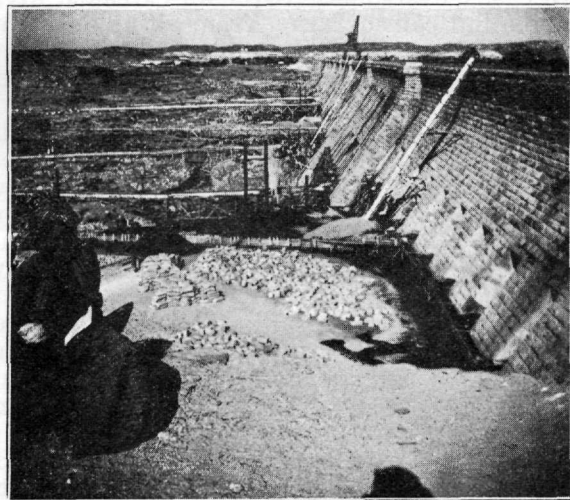
A system of perennial irrigation in conjunction with the basin method was tried in parts of Egypt. This method consists of storing the water in flood season for use during dry weather. The success of this method depends upon some permanent means of storage and control of water.



The Great Assuan Dam

the mouth to the second cataract, a distance of about a thousand miles. This area, a total of six and a quarter million acres of arable land, furnishes food to about twenty millions of people, or about twice the combined population of New York and Chicago. The need of an efficient irrigation system has been keenly felt in Egypt for many years. For centuries the Egyptians lived in fear of dreadful famines. The story of Joseph and Pharaoh's dream will be recalled, how he stored the grain of the seven fat years against the seven lean years which were to follow.

Our familiarity with the great engineering projects in the United States, the Panama Canal (1914), the New York Water Supply, just recently completed, and the proposed Great Lakes-St. Lawrence Waterway, is apt to give us the impression that all the big things in engineering are done in the Western hemisphere. Some wider reading and a consequently broader outlook will soon disprove this popular misconception. The Assuan Dam of Egypt, though from a construction standpoint it may not compare favorably with similar structures in other parts of the world, from the standpoint of service to the masses (by which all engineering success should be measured) deserves a place at the top. The construction of this project was started in 1898 and was finished in 1903. W. G. Bligh, in "Dams and Weirs," says, concerning this project, "No single irrigation of modern times has been more



The Dam from Below

Lack of a responsible head and an efficient means of execution caused the failure of this system. In very wet years when there was some flow the entire year the perennial system was satisfactory, but if the season of dry weather persisted the supply was soon exhausted. As a rule, the Nile is almost dry nine months of the year and is a raging torrent for the remainder.

Some consideration of the economic and indus-

trial conditions of Egypt will give a clearer understanding of the importance of this project as a great work of humanity, as well as a better conception of some of the difficulties encountered by the engineers of the Daira Land Company when they went in there to investigate the irrigation possibilities in 1894. The very nature of the inhabitants increased the difficulty of prosecuting the work. The source of the Nile was not discovered until the middle of the nineteenth century. By the common people this historic stream was looked upon as a mysterious god. Our earliest records show them making sacrifices of first-born children to this all-powerful and destroying deity. Yet they revered it as a great source of food supply. Without it and the annual deposit of rich earth they knew that starvation would result. In a nation which is by nature subdued and superstitious, it is difficult to carry out any work of a progressive nature for which there exists no precedent.

Too much credit cannot be given to Sir William Willcocks and his corps of English engineers, who were responsible for the conception and execution of this great project. The preliminary work was carried on under odds. No assurance that the project was to be the success it has proved to be was to be had at the outset. Very little co-operation was to be had from the very people who were to be benefited the most. The execution of a work of this kind under the above conditions is a good example of engineering faith which is so necessary in a work of this magnitude. But the greatest wonder is that an undertaking which has had such a stupendous effect upon the industrial welfare was not conceived earlier.

The engineering difficulties, though different in character from the political and social, were no more easily overcome. After an extended investigation and consideration from all angles, three possible methods of storing the surplus water of the flood season for use throughout the year were suggested.

The first method suggested was by storing the water in depressions outside the Nile Valley. Long experience with the basin method previously outlined had proved inefficient and unsatisfactory. The loss, upon long storage, due to evaporation and percolation, was too great to make that system practical.

The second method proposed storing the excess water in waste lands of the Delta. If this method were adopted, only a small portion of the land would be benefited. The Delta comprises only about one-fifth of the total arable land.

The last method, the one finally adopted, consisted of storing the water in a reservoir in the valley itself. This final method necessitated the construction of some type of barrier to impound the water. The consideration and selection of a suitable structure called forth more serious study. Again three possible solutions presented themselves; first, by building solid submergible dams over which the floods may discharge; second, by building solid insubmergible dams and turning the Nile through waste weirs; and third, by building insubmergible dams provided with undersluices which are capable of discharging the floods through the dams.

Building solid submergible dams would prove satisfactory where the floods were infrequent and of short duration. Since the Nile floods occur annually and as a rule last for three months, the maximum height of such a structure would be about forty feet with safety. Here the conditions required a much higher dam, so this solution was discarded.

Insubmergible dams provided with waste weirs are suitable for streams with very little sediment or where the slope of the stream is great enough to provide a velocity to keep the silt scoured out of the reservoir. The Nile drops only one foot in about two and a half miles and, consequently, has a very sluggish current. This means a large deposition of alluvium. It was computed by the engineers that about two billion cubic feet of silt pass Assuan annually, or enough earth to cover the entire University lands to a depth of about forty feet. With the reservoir filling this amount each year, a great loss of capacity would result and consequently the entire basin would be filled. It was cited that the Puentes Dam in Spain silted up about fifty feet in just a few years. As a consequence, this method had to be abandoned.

Insubmergible dams with undersluices for discharging the flood through the dam was the only alternative. During the flood season the ports or sluices at the bottom of the dam could be opened to allow the water bearing the silt to pass and then when the water was clear the openings could be closed to impound the surplus water. This type of structure was finally adopted and is in use at the present time.

It remained to design such a dam. A consideration of the geologic formation underlying Egypt will give some conception of the difficulties in building such a structure. Possibly the first requisite of any engineering structure is the foundation. Unless the base is founded upon safe principles the whole structure may fail. The history of masonry dams shows that the larger majority of failures of dams is due to foundation failures. To be absolutely safe the foundation of a dam should be upon solid rock. This requirement, then, was one of the prime factors governing the location of Assuan Dam. It is commonly known that the Nile Valley is of deltaic origin, that is, it has been produced by the constant deposition of sediment at the mouth which continually moves farther out into the body of water into which the stream discharges. Under conditions such as this, the possibility of finding solid rock for foundation is very remote without going to such depth as to make the construction economically impossible. This condition fixed the location at one of the cataracts where the rock outcrops. Another condition affecting the location was the number of people served. In considering this condition, the greater the distance from the mouth the more irrigable the land.

A location a few miles below Assuan, near Silsila, was suggested, but a test of the Nubian Sandstone at that location showed it unfit for masonry. The site at Assuan was finally chosen on account of the rock outcrop for foundation, the fine granite for the masonry, and the great width of the stream at that point, which reduced the necessary height appreciably. The enormous

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volume of water impounded made this latter precaution necessary. This type of dam is in direct contrast to those usually built in the United States, where the site is usually chosen where the valley narrows down to a gorge. The extreme width of the Nile at this point necessitated the use of a dam more than a mile and a quarter in length, or about six times as long as the O'Shaughnessy Dam now under construction for the Columbus Water Supply. Owing to the irregularities of the stream bed, the height varies from a few feet to one hundred and twenty-five. It is twenty-three feet wide on top and about eighty-one at the widest point at the bottom.

Lying just above Assuan in the middle of the Nile is the Island of Philae, upon which is situated the famous Temple of Philae. The design of the original dam was of such height as to completely submerge this temple. The engineers suggested that the temple be removed and reconstructed at another site. This suggestion met with much disfavor among archæologists all over the world. The officials were beset with petitions beseeching them to spare the temple. As a result the design was changed and a dam about twenty-five feet lower was finally adopted. This procedure was a mistake, and it was realized before the dam was in operation a year. The people were soon crying for more water. A few years later the dam was raised to the original elevation and the previous proposal to remove the temple was carried out.

General sanitation offered another objection to the construction of this work. The committee on sanitation held that the impounding of the water would lead to stagnation and a consequent injury to health, due to the penetration of the stale water to the drinking supply. Investigation showed that under the proposed system conditions could be no worse than those already existing.

The construction of this project occupied about five years. The work was done by contract. John Aird and Son, of London, were the contractors on the original work and they also raised the structure about 1910. The original structure was finished in 1903.

The bulk of the masonry is local granite. The exposed surfaces are, with the exception of the sluices, of course, rockfaced ashlar, which is roughly rectangular stone blocks laid with thin joints. The sluices are all lined with finely dressed stone, with the exception of thirty, which are lined with cast iron. The interior masonry is handlaid rubble or irregular stone blocks laid in Portland cement mortar, of which forty percent is mortar.

The total cost of the project was about twelve millions of dollars. The direct computed benefit to the land is, in round numbers, twenty millions of dollars. This figure is, however, but an infinitesimal part of the great benefit to the peoples of Egypt.

At present this is the largest masonry dam in the world. It will be exceeded, however, as an engineering structure by the Wilson Dam at Muscle Shoals, Alabama, which is now under construction.

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The writer wishes to acknowledge his indebtedness for much of the information contained herein to Sir William Willcocks, whose book, "Egyptian Irrigation," is highly recommended to any who are further interested. Acknowledgment is also made to Engineering News-Record.

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